Forage Genetics and Production

Yield and Nitrogen Fixation of Annual Medics

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Introduction

Annual medics are winter annual legumes used in the Australian ley farming system, which integrates leguminous pastures into cereal production systems. The ley system produces improved soil fertility and higher subsequent cereal yields. Annual medics also contribute some symbiotically fixed nitrogen (N) to intercropped grasses. In the North Central USA, annual medics have been evaluated for potential use as summer annual forage sources, as smother plants for weed control in corn, and as intercrops with small grains. Information on N contribution of annual medics in these and other cropping systems, however, is needed to determine optimum N management.

Our objectives were to: 1) describe the aboveground biomass accumulation pattern of spring seeded annual medics in Minnesota, and 2) estimate the proportion and amount of N derived from the atmosphere by spring seeded annual medics using the isotope dilution and difference methods.

Methods

Field experiments to determine dry matter accumulation patterns were conducted at Becker, Minnesota, on a Hubbard loamy sand in 1993 in 1995. Four annual medic species, *Medicago truncatula* vs. Mogul, *M. polymorpha* cv. Santiago, *M. scutellata* cv. Sava, and *M. rugosa* cv. Sapo, were planted in the spring in rows spaced 15 cm apart within 3- by 6-m plots at the rate of 484 live seeds m^{-2}. All medics were inoculated with commercial inoculant (a mixture of 5 rhizobial strains) specially selected for annual medics. Plants were sampled beginning 14 days after planting until maximum dry matter was accumulated, which was in early to mid-August. Harvest intervals averaged 12 days in 1993 and 18 days in 1995. Herbage was removed from a 0.2-m^2 area and samples were dried at 60 °C and then weighed. The experimental design was a randomized complete block with treatments in a split plot arrangement. Medic species were main plots and sampling times were subplots. There were six replicates.

Field experiments to estimate symbiotic N_2 fixation were conducted at Becker (1993 and 1994) and at Rosemount (1993), Minnesota. The soil at Rosemount was a Tallula silt loam. Noninoculated *M. rugosa* was used as a reference crop because it is poorly nodulated by indigenous rhizobia. 'Surrey' annual ryegrass (*Lolium multiflorum*) also was grown as a reference crop. Ryegrass was seeded in 15-cm rows at a rate of 1120 live seeds m^{-2}. Ammonium sulfate enriched to 99.4 atom % ^{15}N was applied at a rate of 1.2 kg N ha^{-1} as an aqueous solution on a 2-m^2 subplot within each plot 10 days after seeding. The central 1 m^2 of each plot was harvested in August, when maximum herbage dry matter was reached. Samples were dried, ground, and then analyzed for total N and ^{15}N on an integrated combustion analyzer-mass spectrometer. Standard isotope dilution and difference equations were used to calculate N derived from the atmosphere (Ndfa).

Results and Discussion

Herbage dry matter increased for most medics until 72 days after planting, but *M. polymorpha* did not achieve maximum dry matter yield until 84 days after planting. Dry matter yields averaged about 9100 kg ha^{-1} in 1993 and 5000 kg ha^{-1} in 1995. Yields of the inoculated *M. rugosa* were 8000 kg ha^{-1} in 1993 and 4700 kg ha^{-1} in 1995, whereas noninoculated *M. rugosa* yields were 3500 kg ha^{-1} in 1993 and 870 kg ha^{-1} in 1995, respectively, indicating lower N supply via symbiotic fixation. Nodules were present on the roots of all inoculated medics at the first sampling, 14 days after planting.

Based on the isotope dilution technique, herbage of annual medics at maximum dry matter accumulation contained an average of 86% Ndfa, using ryegrass as the reference crop, or 79% Ndfa, using noninoculated *M. rugosa* as the reference crop. Higher %Ndfa with ryegrass was likely due to its shallower, more fibrous root system and the possibility of small rates of N_2 fixation by the noninoculated *M. rugosa*. We found very few nodules on roots of the latter crop, and conclude that results based on *M. rugosa* probably are more representative than those with ryegrass. At Becker, the %Ndfa was similar for all annual medic species, but at Rosemount, %Ndfa was higher for *M. polymorpha* (81%) than for *M. scutellata* and *M. rugosa* (72%). The correlation between %Ndfa based on the isotope dilution technique and based on the difference technique was 0.88 ($P = 0.01$, n = 12) when noninoculated *M. rugosa* was the control crop.

Based on the isotope dilution technique, the amount of Ndfa in annual medic herbage ranged from 101 to 205 kg N ha^{-1}. At both locations, *M. polymorpha* had the highest Ndfa, whereas *M. rugosa* had the lowest. The correlation coefficient for estimates of Ndfa by the isotope dilution technique and the difference technique was 0.998. This suggests that the simpler, less expensive difference technique could be used to evaluate symbiotic N fixation in annual medics. Nevertheless, we recommend that the isotope dilution technique be used on soils that have abundant inorganic N supplies, because our other research has indicated that substantial differences in soil N uptake can occur between N_2 fixing and nonfixing species.

Our results indicate that annual medics may provide a good source of symbiotically fixed N in cropping systems in northern climates. Their growth habit supports relatively high N fixation rates, and maximum dry matter and N accumulation can be achieved within 70 to 85 days after spring planting.